Space Weather Technical Forecast

Issued on Wednesday 1 January 2025 at 01:24 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: R1/R2 Radio Blackouts expected with a slight chance of R3 blackouts. A CME arrival is expected on 1st Jan, with G1-G2 Minor/Moderate storm likely, with a slight chance of G3 Strong storm.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with three M-class flares during the past 24 hours, the peak being an M2.9 flare from AR3938 at 31/2250 UTC. AR3936 also produced a long duration flare, peaking at M2.7 at 31/2218 UTC.

There are currently nine sunspot regions on the visible disc, eight of which are numbered. AR3936 in the northwest remains the largest and most active region, with a Eki/beta-gamma-delta classification. AR3938, AR3939 and AR3941 are moderately complex, but relatively small in size, with the remaining regions very small and magnetically simple. The majority of regions have shown little or no change over the past 24 hours, the expectation being AR3944 which emerged close to where previous region AR3642 had faded to plage in the southeast.

No Earth directed CME's were observed in available imagery.

Solar Wind / Geomagnetic Activity: A CME arrived at L1, as observed by ACE, at 31/1544 UTC and then at Earth at 31/1626 UTC. The CME is attributed to the filament eruption near AR3939 at 29/0436 UTC.

Before the CME arrival solar winds, as observed at L1 by ACE, were at background levels between 330-350km/s. The density was below average, and the Interplanetary Magnetic Field (IMF) was weak but quickly increased to moderate levels between 8-11 nT. The north-south component was predominantly weak and variable, ranging from -8nT to +8nT. Phi angle was mostly positive (away from the Sun). Geomagnetic activity was Quiet (Kp 1-2).

After the CME arrival solar winds increased to around 450km/s, peaking at 489 km/s at 31/1716 UTC. The density increased to above average, and the Interplanetary Magnetic Field (IMF) quickly increased to strong levels, peaking at 27 nT at 31/1735 UTC, then declined to moderate levels by the end of the day. The north-south component reached -18 nT at 31/1859 UTC, then gradually became only weakly negative by the end of the period. Phi angle remained positive (away from the Sun). Geomagnetic activity increased to Active (Kp 4) levels.

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Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES18 remained at background throughout, well below the S1/Minor Radiation Storm threshold.

High energy electron flux (greater than 2MeV) at GOES16 was at mainly at Background levels, diurnally increasing to Moderate levels, peaking at 31/1715 UTC at 506 pfu. The associated 24-hour fluence was below the Active (1e8 integrated flux) threshold on a slightly increasing trend. The 31/0001UTC observation was 4.68e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Generally Moderate solar activity is expected with isolated M-class flares, and a slight but declining chance of isolated X-class flares, mainly from AR3936 which will rotate onto the far side through the forecast period.

Solar Wind / Geomagnetic Activity: No coronal hole fast winds currently feature in the forecast. A partial halo CME was observed from AR3939 late on the 29 Dec, with the potential to reach Earth on Day 1 (01 Jan), however little material is expected with this second CME and so impacts are expected to be limited, most likely to prolonged slightly enhanced geomagnetic activity from the CME arrival on the 31st.

Geomagnetic activity is expected to to be predominantly Unsettled to Active (Kp 3-4) today (01 Jan) but with isolated G1-G2 Minor/Moderate storm (Kp 5-6) intervals likely. The CME effects will gradually wane through days Day 2 and 3 (02 and 03 Jan), back towards Quiet to Unsettled conditions.

Energetic Particles / Solar Radiation: There is a chance of S1/Minor Radiation Storm enhancements during the period from any significant flares, initially most likely from AR3936 and AR3938. Electron flux levels are expected to remain at Background to Moderate. Electron fluence will is expected to persist below the Active threshold.

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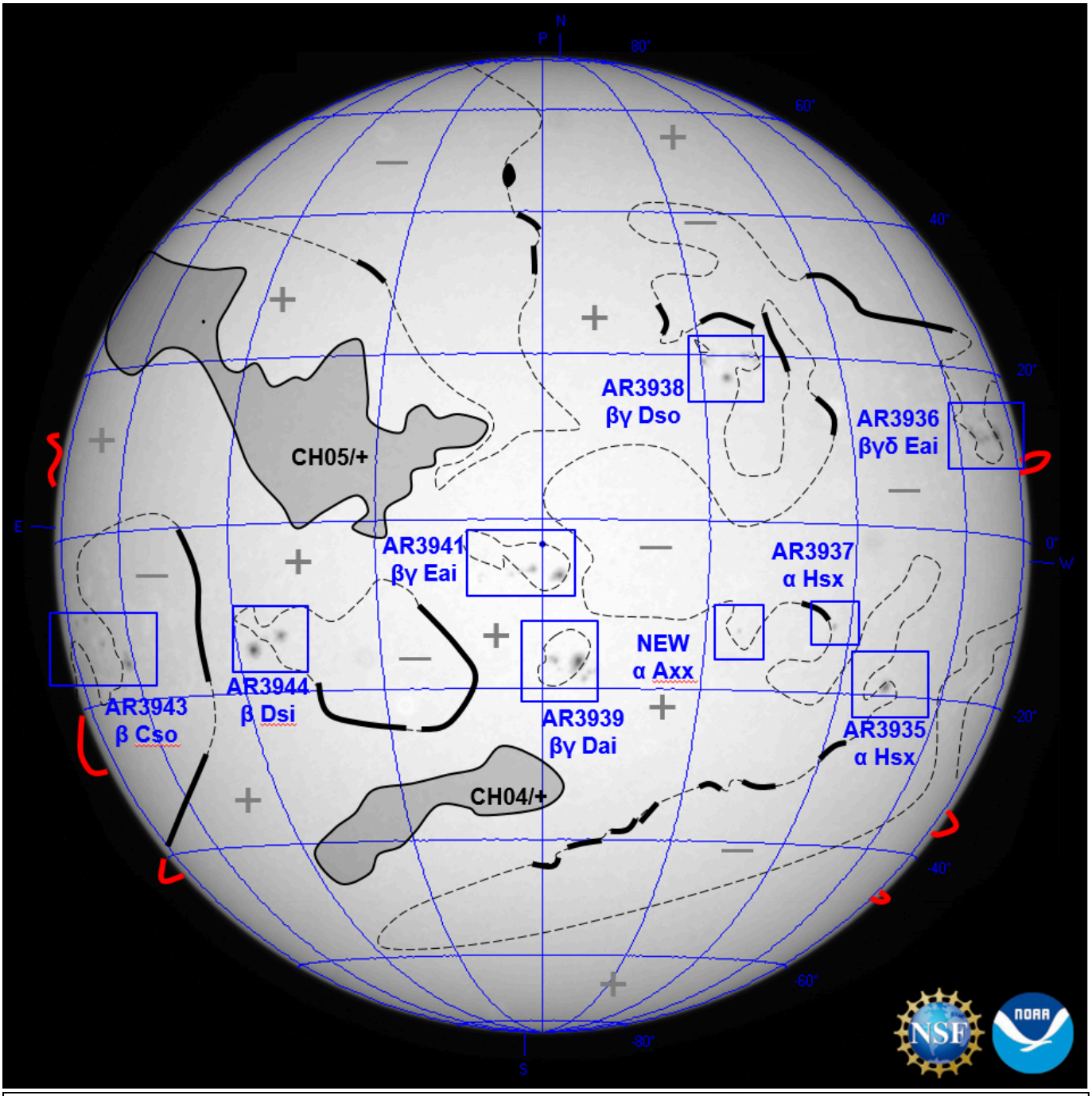
Figure 1: Synoptic map 31/1944 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

A partial halo CME was observed leaving the Sun late on the 29 Dec in association with a M3.3 flare from AR3939 in the southeast, and is expected to reach Earth today (01 Jan). However, the CME potentially arriving today does not appear to be much material associated with the shock, and therefore any impacts will be limited and more likely to maintain the existing enhancements of the CME arrival on the 31st.

No coronal hole high speed streams feature in the forecast.

Geomagnetic activity is expected to to be predominantly Unsettled to Active (Kp 3-4) today (01 Jan) but with isolated G1-G2 Minor/Moderate storm (Kp 5-6) intervals likely. The CME effects will gradually wane through days Day 2 and 3 (02 and 03 Jan), back towards Quiet to Unsettled conditions.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	60	30	10	5
Strong	G3	No	5	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
2024-12-29 (2310 UTC)	Partial	AR3939	Southeast	697 km/s	2025-01-01 (0900UTC)	M3.3 flare from AR3939

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Figure 2: Latest MOSWOC Enlil

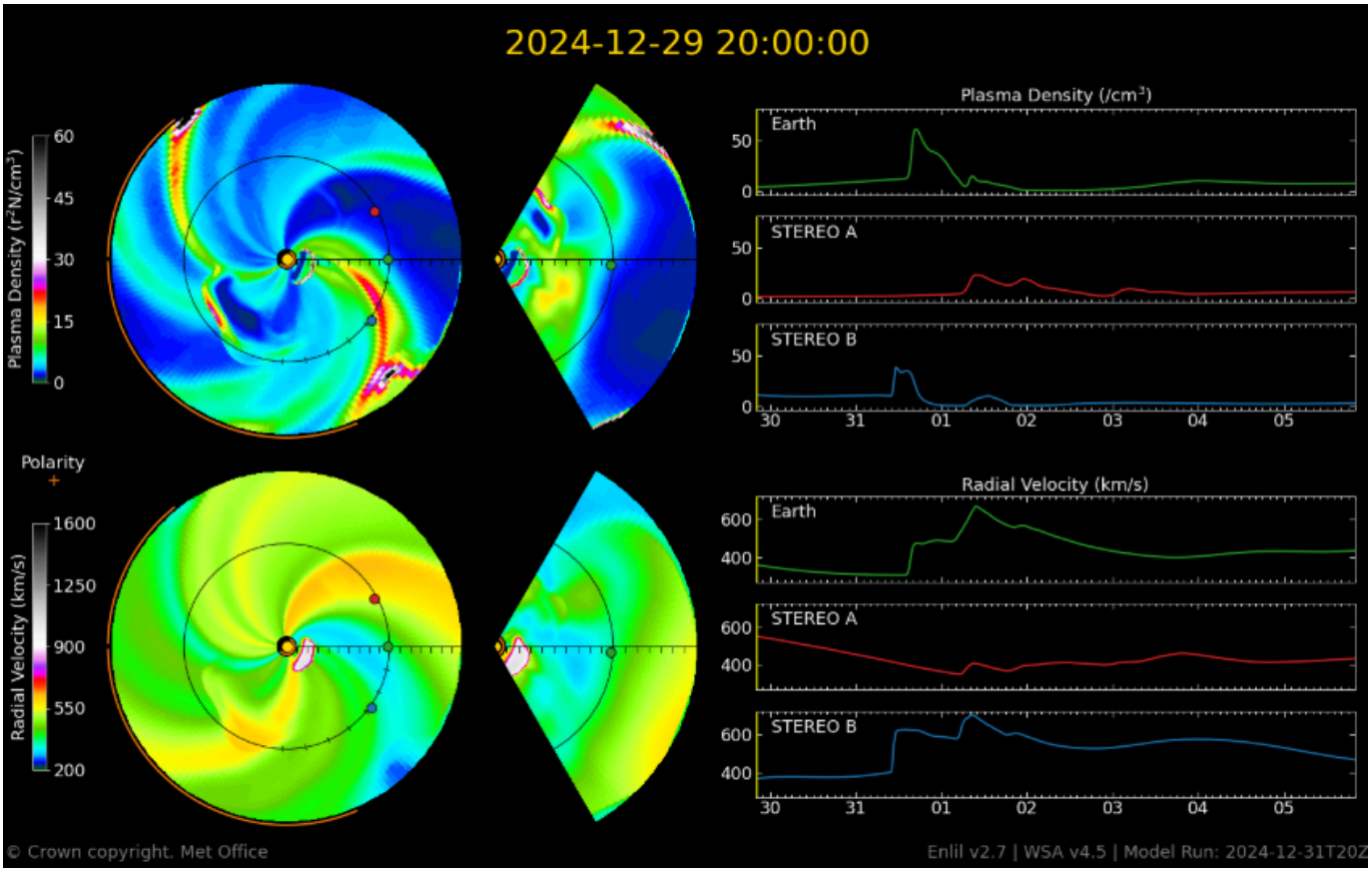
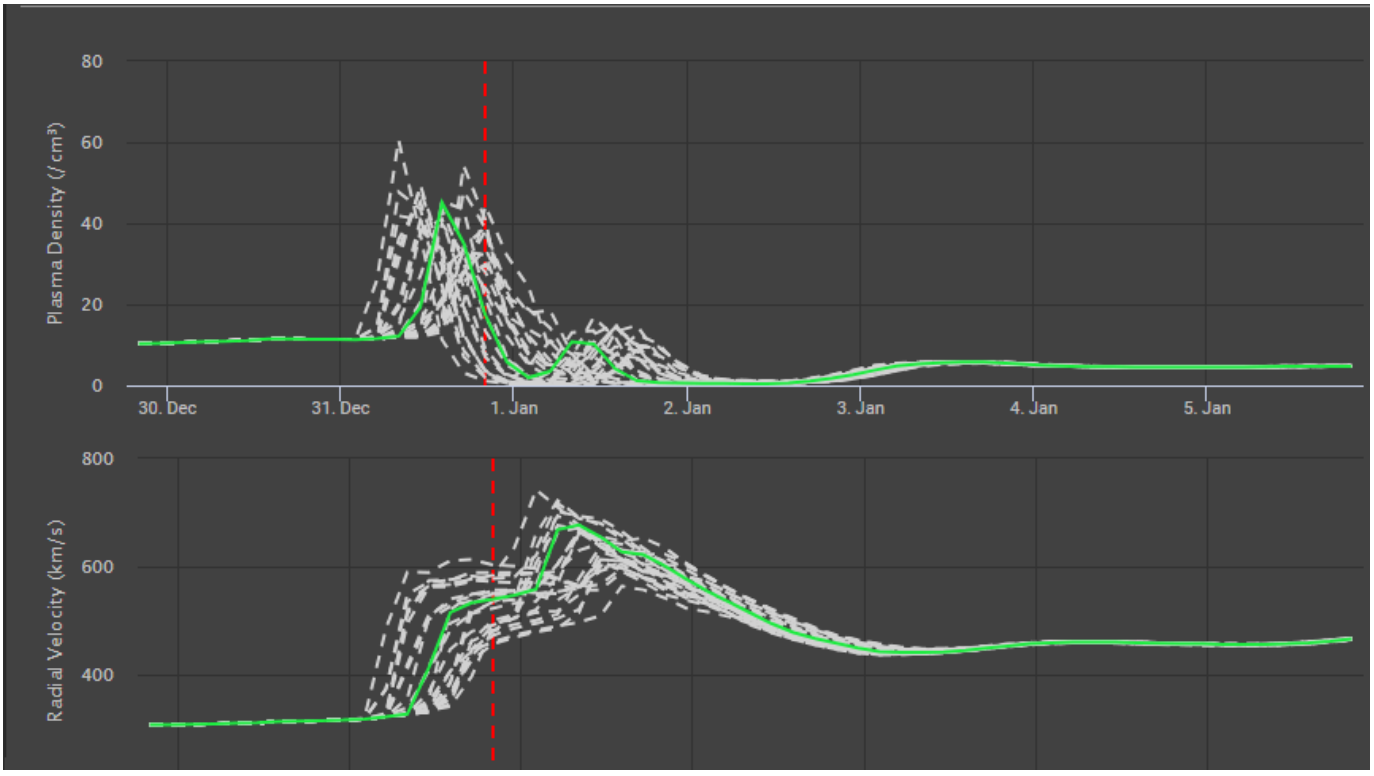


Figure 3: Latest MOSWOC Enlil Ensemble



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Radio Blackouts - X-Ray Flares

Solar activity has been moderate over the past 24 hours. There are currently nine sunspot regions on the visible disc, with previous region AR3932 fading from view and a new simple region in the southwest quadrant. AR3936 in the northwest remains the largest region and probably the most complex, but is now becoming harder to analyse as it approaches the west limb. The previous classification has been retained, but with low confidence. AR3939 shows some complexity with positive polarity spots surrounding negative spots in the centre, perhaps showing some indication of its centre spot getting closer to the smaller leading spots. AR3938 and AR3941 appear to be stable. AR3944 has rapidly increased in complexity in the last 24 hours, going from a simple Bxo classification to a Dsi and is one to be watched. AR3943 in the southeast remains difficult to analyse due to its oblique viewing angle, but should become clearer as it rotates further onto the disc. The remaining regions are small and magnetically simple.

Moderate solar activity is forecast with isolated Moderate flares expected and a slight chance of isolated X-class flares, especially from AR3936. However, as this region will rotate off behind the west limb during the period so the chance of significant flares decreases.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	70	50	40	40
Very Active	R3-R5 (X Class)	No	15	5	1	1

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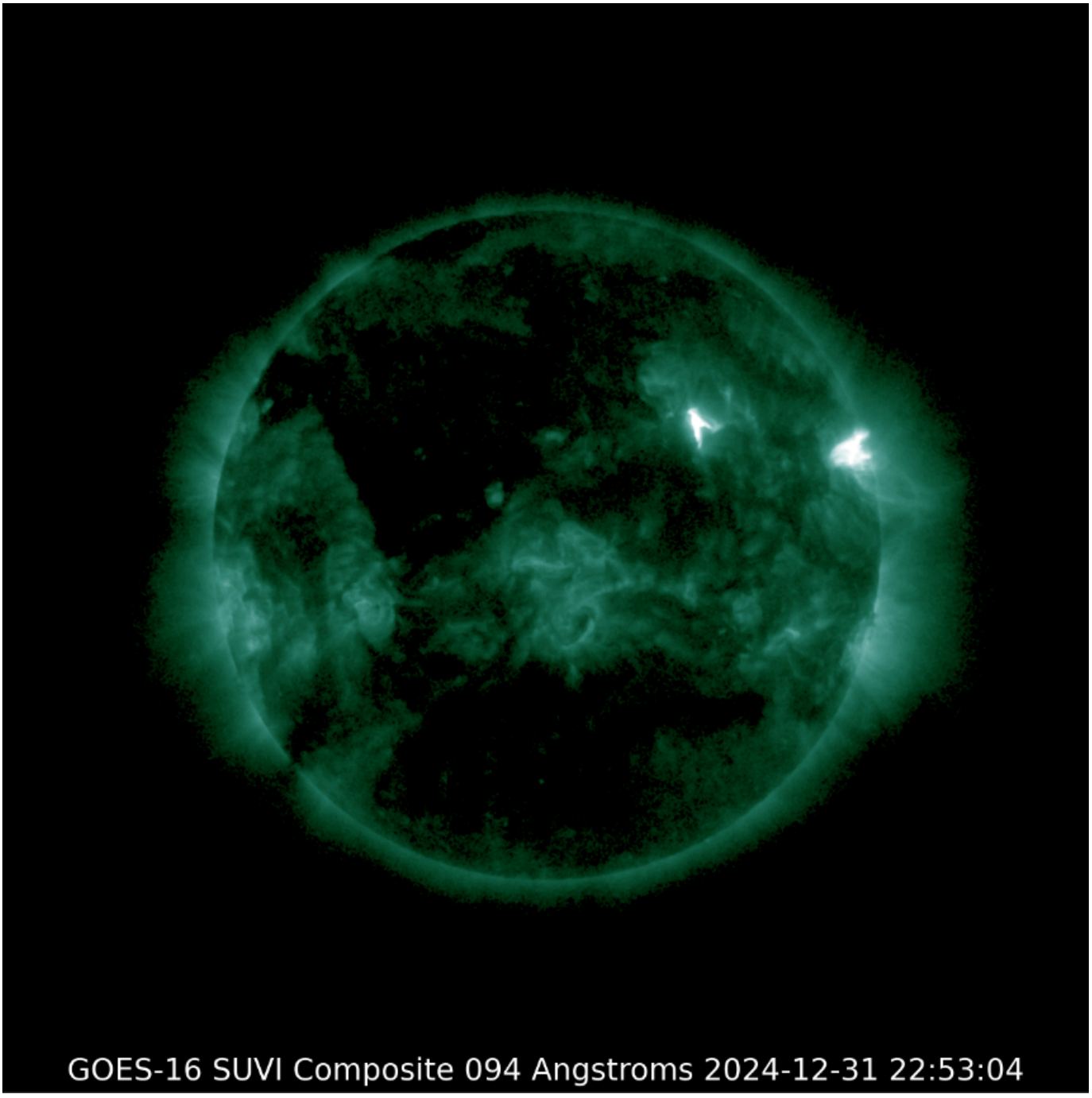
Figure 4: M-class flares from AR3936 and AR3938.



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Solar Radiation Storms (High Energy Protons)

High energy proton counts remain at Background values. There remains a slight chance of S1/Minor Solar Radiation storms should any significant flares occur from the larger regions in the western hemisphere, initially most likely from AR3936 and AR3938.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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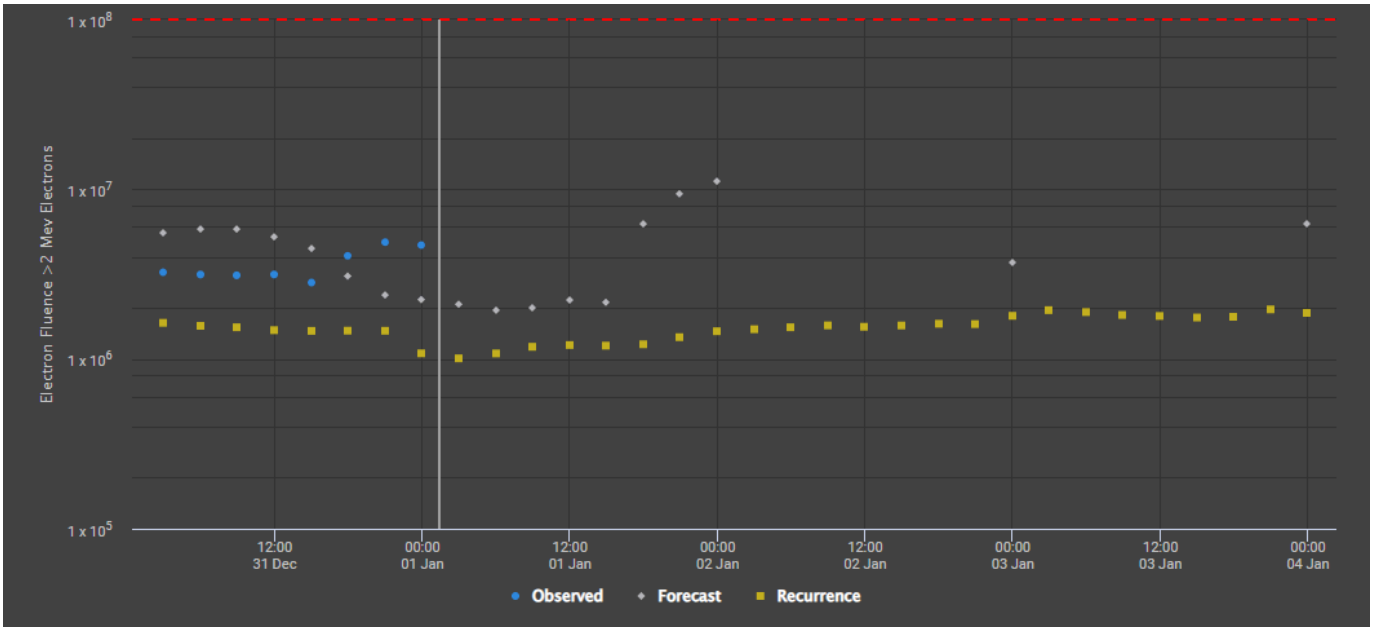
High Energy Electrons (≥ 2MeV)

High energy electron flux has remained at Background, with diurnal peaks up to Moderate levels in the last 24 hours. Electrons are likely to appear slightly suppressed with the CME arrival yesterday (31 Dec) and possibly with the next CME arrival expected today (01 Jan). as the Van Allen belt becomes compressed away from the location of GEO. This may expand late in the forecast period, seeing a rise in the electron levels. Electron fluence is expected to remain below the Active threshold throughout, as shown in MOSWOC REFM output, which is considered good guidance.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	5	5	10	20
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 5: MOSWOC REFM model



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